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(71) Applicant (*for all designated States except US*): PROGENITIVE SERVICES LIMITED [GB/GB]; Badentoy Avenue, Portlethen, Aberdeen AB12 4YB (GB).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): GRAVES, Leslie, John [GB/GB]; Dunreggan, Slug Road, Stonehaven, Aberdeen AB39 2DU (GB).

(74) Agent: MURGITROYD & COMPANY; 165-169 Scotland Street, Glasgow G5 8PL (GB).

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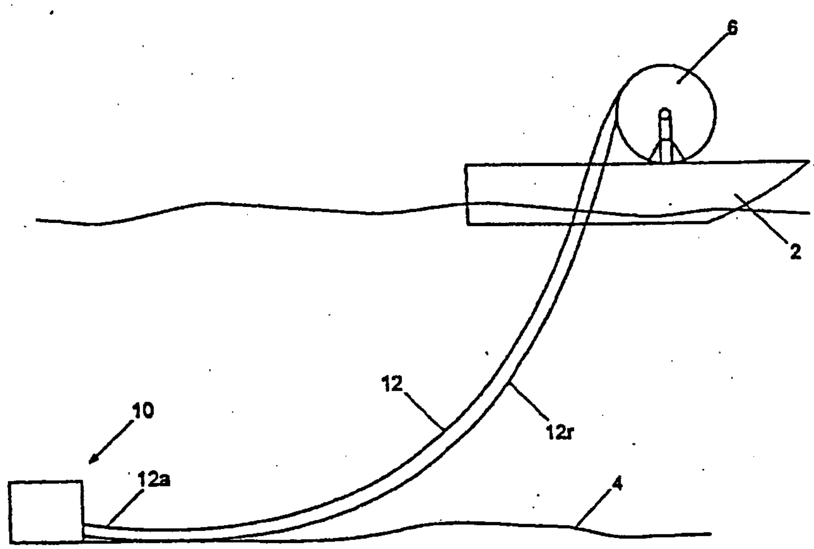
(54) Title: METHOD OF FLOODING A PIPELINE



(57) Abstract: A method of flooding a pipeline (12) as it is being laid is disclosed. The method includes the use of an inlet to the pipeline that is attached to an end of the pipeline (12) either before the pipeline (12) enters the water or shortly thereafter. Water enters the pipeline (12) via the inlet as the pipeline (12) is laid, typically due to the hydrostatic head of water above the inlet, and the pipeline (12) is consequently flooded from one end (12a) as it is laid. Certain embodiments provide for chemicals to be added to the water as it floods the pipeline (12). Certain other embodiments also provide for filtering (14) of the water as it enters, and also there is the option for pressure testing the pipeline (12) once laid.

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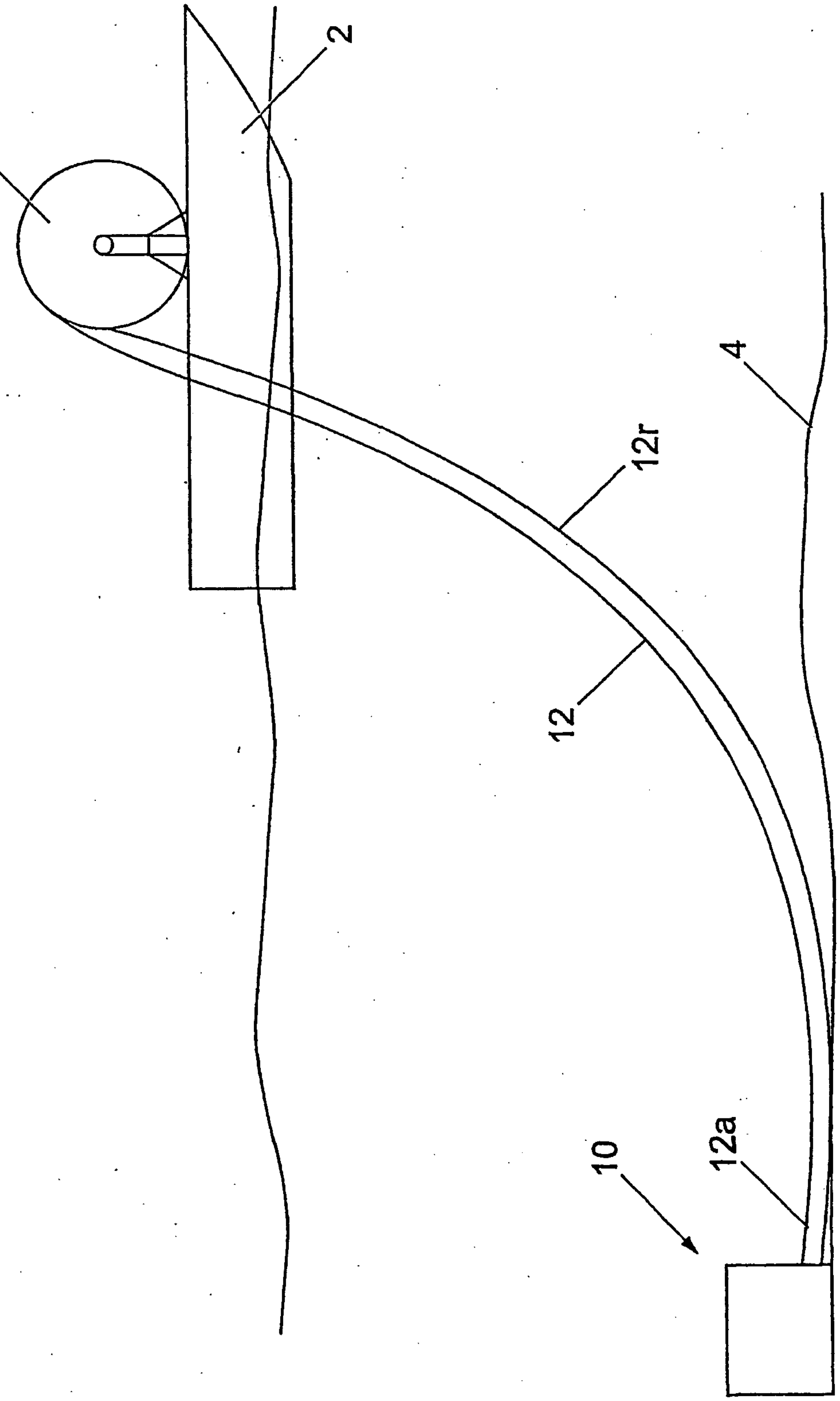

Fig. 1

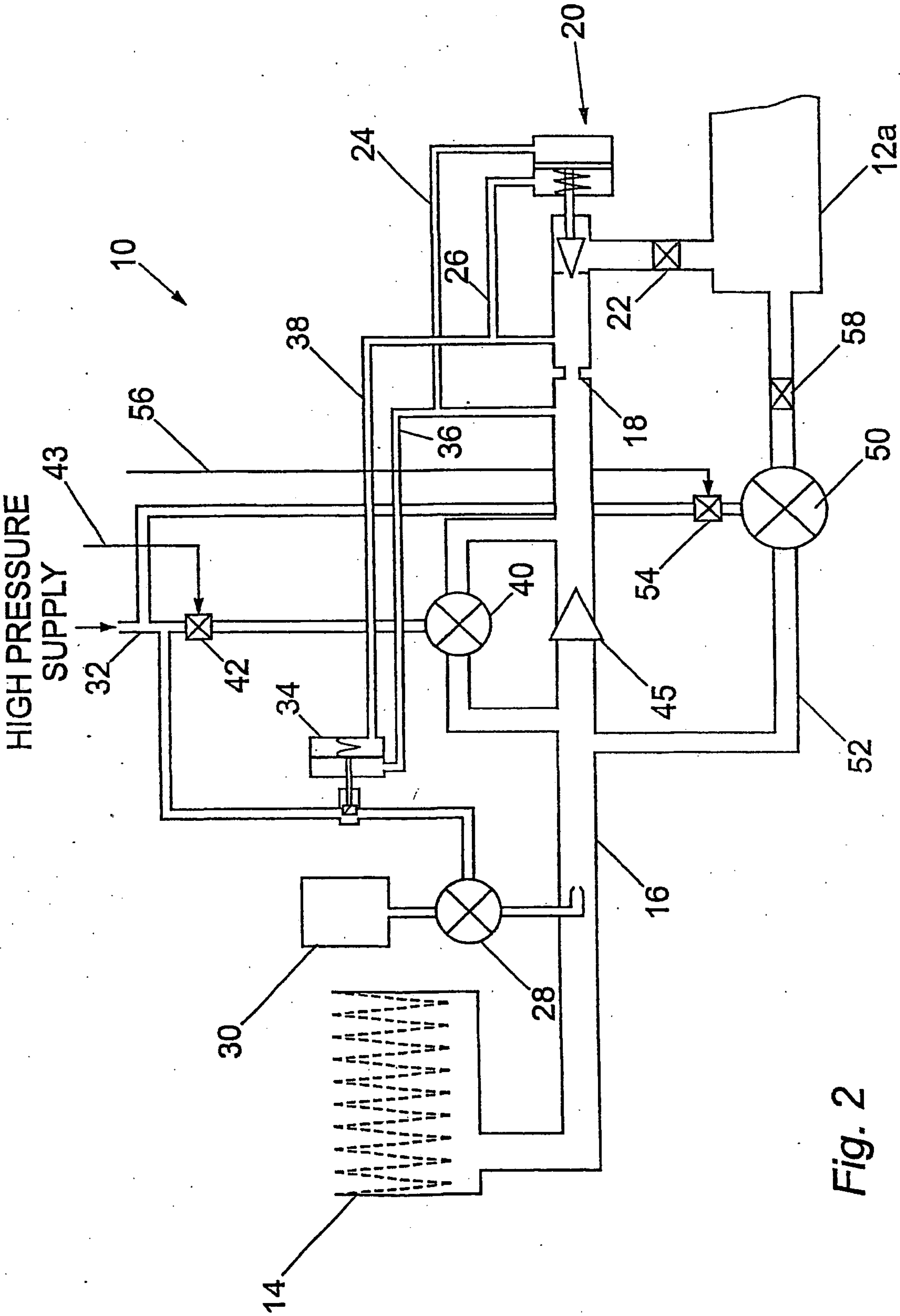
HIGH PRESSURE SUPPLY
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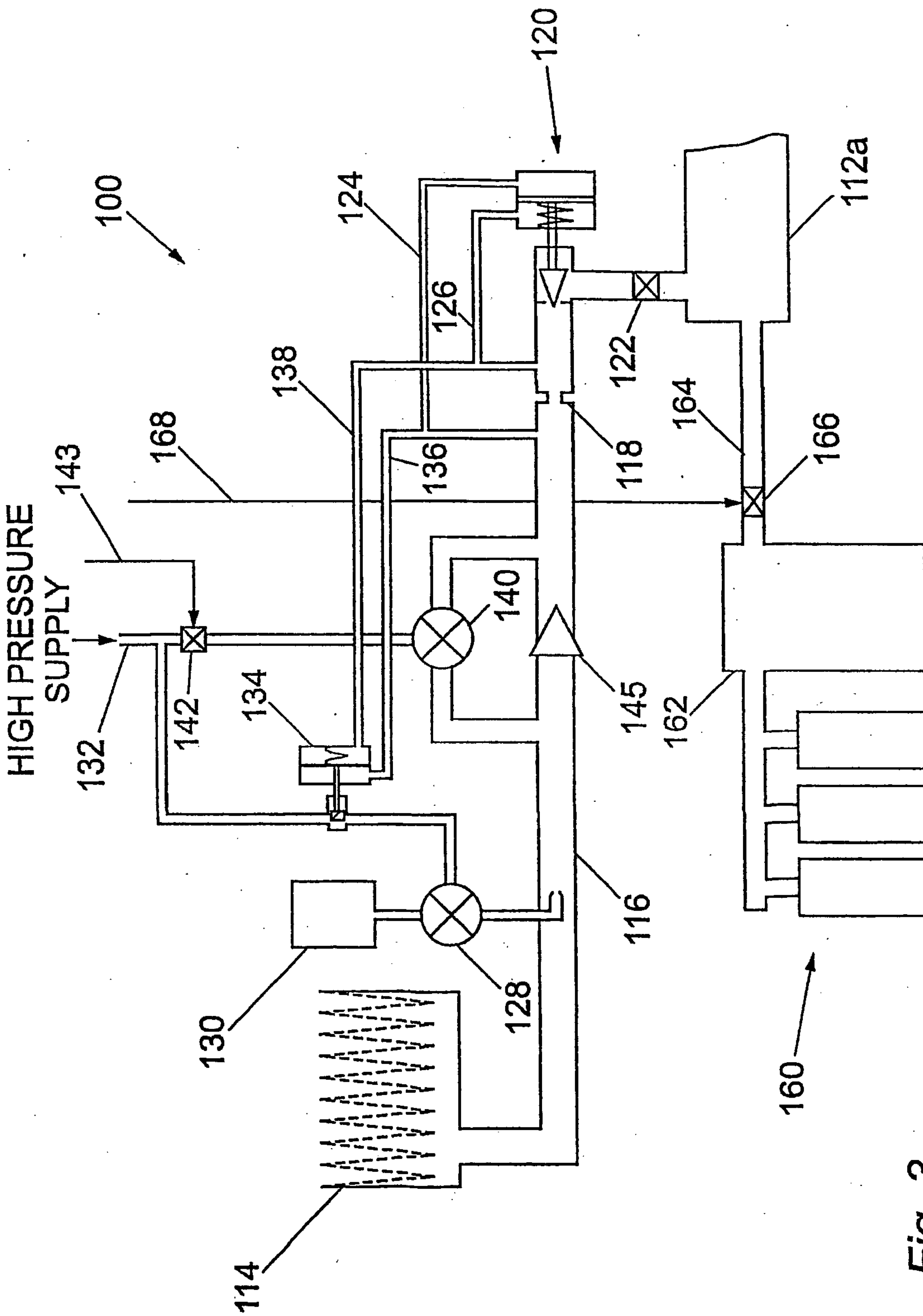
Fig. 2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HIGH PRESSURE SUPPLY
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Fig. 3

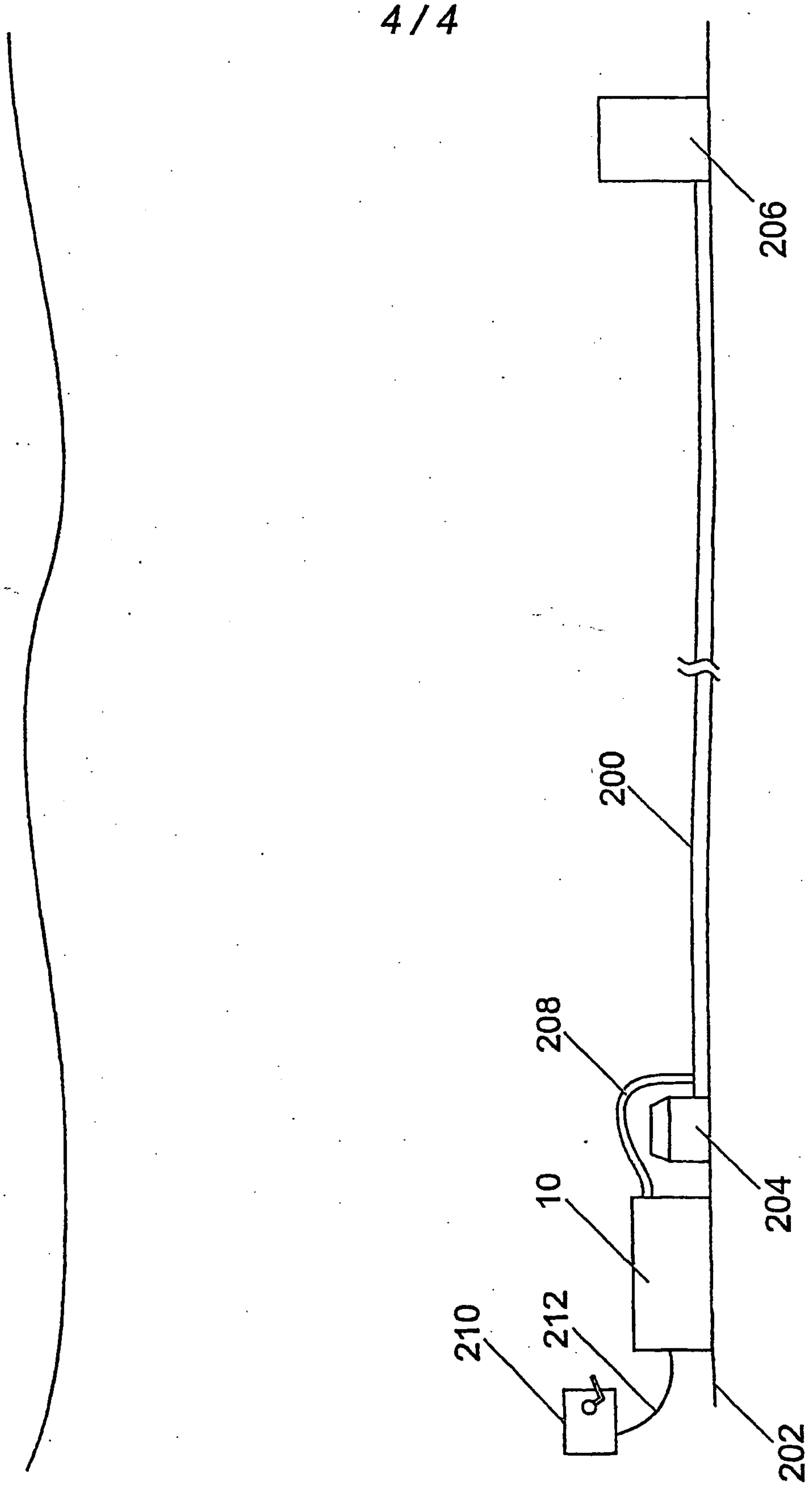

Fig. 4

"Method of Flooding a Pipeline"

The present invention relates particularly, but not exclusively, to a method of flooding a subsea pipeline as it is being laid from a lay barge, vessel or the like.

The laying of a subsea pipeline from a lay barge or vessel is well known in the art, and a number of different methods exist, such as J-lay, S-lay etc. Although the specific methods of laying the pipeline can vary, they all share a common problem in that the pipeline is generally relatively buoyant and can be affected by storms and tides that can move the pipeline.

To deal with this long-recognised problem, it is conventional to increase the wall thickness of the pipeline to make it heavier and less prone to movement, and this increase can be around an eighth of an inch (approximately 3mm) or more. This has the advantage that the pipeline is made heavier and thus less susceptible to movement by storms and tides.

The movement of the pipeline by storms and tides can be reduced by laying the pipeline into a trench formed in the seabed.

According to the present invention, there is provided a method of flooding a pipe as it is being laid in water, the method comprising the steps of providing an inlet to the pipe, the inlet having an opening to admit water, and allowing water to enter the pipe through the inlet as the pipe is being laid.

The invention also provides a method of laying a pipeline in a body of water, the method comprising allowing the water to flood the pipe as it is being laid.

The inlet is typically coupled to the pipe via a pipe inlet port, and thus the method typically includes the additional steps of coupling a pipe inlet port to the pipe, and coupling the inlet to the pipe inlet port.

The method typically includes the additional step of coupling the inlet to the pipe before the pipe enters the water. Alternatively, the method typically includes the additional step of coupling the inlet to the pipe underwater. The coupling of the inlet to the pipe underwater may be achieved by use of a diver, remotely operated vehicle (ROV) or an autonomous vehicle (AUV).

The method typically includes the additional step of actuating flooding of the pipe. The step of actuating flooding of the pipe typically involves opening an isolating valve located in the inlet (or at another suitable location). The isolating valve can be opened at the surface, or underwater by a diver, ROV or AUV. Alternatively, the isolating valve may be opened remotely (e.g. using a control line from the surface).

The method preferably includes the additional step of filtering the water that enters the pipe. Thus, the method typically includes providing an intake filter at the inlet.

The pipe is typically flooded from the end that is in the water, rather than from the end of the pipe that remains on the lay barge. Embodiments of the present invention provide significant advantages in that the hydrostatic head of water above the pipe (i.e. the pressure difference between the air- or gas-filled interior of the pipe and the surrounding water) can be used to flood the pipe. Thus, a pump may not be required.

Flooding the pipe from the end that is underwater means that the end of the pipe that is on the barge (that is the remainder of the pipe that has not been laid) can provide a vent to the atmosphere for the air or gas in the pipe during flooding.

Embodiments of the present invention also provide the advantage that the flow of water into the pipeline can be controlled, and thus the pipe is less likely to be moved during flooding.

Furthermore, flooding of the pipe whilst it is being laid has the advantage that the pipe is made relatively heavy shortly after it enters the water, yet it is not excessively weighted before then. Thus, it is less susceptible to storms, tides and other adverse weather and sea conditions, whilst being easy to handle.

The method optionally includes the additional step of adding chemicals to the water that enters the pipe.

The method typically includes the additional step of pumping fluid into the pipe to complete flooding of the pipe. This can be done by a boost pump where the pressure difference between the interior of the pipe and the surrounding seawater diminishes, and flooding of the pipe ceases. The boost pump can be actuated using a remotely operated valve and a control line, or can be actuated by a diver, ROV or AUV. Alternatively, the boost pump may be actuated automatically in response to a drop in the flow rate of water into the pipe. Thus, the method typically includes the additional step of actuating a pump, typically a boost pump, to complete flooding of the pipe.

The method optionally includes the additional step of pressure testing the pipe after it has been flooded. The step of pressure testing the pipe typically involves the actuation of a subsea pump, although other methods of pressure testing may be used.

The pipe typically comprises a pipeline, and preferably a subsea pipeline.

GB2303895B, the entire disclosure of which is incorporated herein by reference, describes a suitable underwater pipeline apparatus for admitting water into the pipeline in a controlled manner, typically through a flow regulator and a filtration system.

Embodiments of the present invention shall now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1 is a schematic representation of a subsea pipeline being laid from a lay barge;

Fig. 2 is a schematic representation of apparatus for flooding a pipeline;

Fig. 3 is a schematic representation of alternative apparatus for flooding a pipeline; and

Fig. 4 is a schematic representation of a pipeline laid on the seabed between two subsea installations.

Referring to the drawings, Fig. 1 shows a schematic representation of a subsea pipeline 12 being laid from a lay barge 2. The lay barge 2 can be of any conventional type and can use any one of a variety of different pipeline laying methods, such as J-lay, S-lay etc. The pipeline 12 is laid directly onto the seabed 4, and in this particular example, the pipeline 12 is not laid into a trench or the like, although this may be an option. The stability of pipeline 12 in rough weather or sea conditions will be increased where it is laid into a pre-defined trench.

The pipeline 12 may be of any conventional size and type, and is generally initially air- or gas-filled as it is paid out from a reel or drum 6, or coupled together in successive lengths on the lay barge 2. Thus, the pipeline 12 is relatively light and can be affected by storms and tides when it is being laid, and after it has been laid.

Apparatus 10 (best shown in Fig. 2) for flooding the pipeline 12 is attached to an end 12a of the pipeline 12 and is used to flood the pipeline 12 typically with seawater, as the pipeline 12 is laid onto the seabed 4. The end 12a is typically the end of the pipeline 12 that enters the water first. This may be at the beginning of the laying process or can be at any intermediate point should the process be stopped and re-started, for example due to adverse weather conditions. Fig. 1 shows the apparatus 10 already located on the seabed 4, but it is preferably attached to end 12a of the pipeline 12 on the lay barge 2 and can then be lowered to the seabed 4 with the end 12a of the pipeline 12 as it is laid.

Apparatus 10 can be lowered to the seabed 4 using any conventional method or apparatus, such as a crane. It will be appreciated that apparatus 10 can be coupled to end 12a at any convenient time, and it is typically coupled before the end 12a of the pipeline 12 enters the water, although this is not essential. For example, a diver or ROV could be used to couple apparatus 10 to end 12a just after the end 12a has entered the water.

The pipeline 12 is thus flooded from the end 12a that is in the water. Flooding the pipeline 12 from the end 12a that is underwater allows the hydrostatic pressure difference between the interior of the pipeline 12 that is typically initially air- or gas-filled and the surrounding water to be used to flood the pipeline 12. Thus, there is generally no requirement for a pump with a large capacity. A pump of lesser capacity may be required to flood the pipeline 12 if the hydrostatic pressure equalises.

As the water enters the pipeline 12 from the end 12a that is underwater, the pipeline 12 can be vented to atmosphere through the distal end on the barge 2. This can provide advantages in that it may not be necessary to vent the pipeline 12 underwater.

Flooding the pipeline 12 from the end 12a that is in the water provides the advantage that the pipeline 12 can be flooded with relatively little movement of it. This is because the pipeline 12 is progressively flooded from the end 12a as it is being laid, and the flow of water into it can be controlled. The control over the flow rate provides the advantage that the water does not cascade into the pipeline 12 in an uncontrolled manner where excessive flow rates may cause movement of the pipeline 12. Furthermore, the water that is used to flood pipeline 12 flows progressively along it as it is being laid. The pipeline 12 will therefore flood gradually from end 12a as it is paid out from the lay barge 2.

Apparatus 10 and the use thereof to flood pipelines has been described herein with reference to the laying of pipelines in the sea and the flooding thereof using seawater, but it will be noted that the pipeline 12 may be laid in a lake or the like and flooded with fresh water, rather than seawater.

Referring now to Fig. 2, an exemplary embodiment of apparatus 10 for flooding of the pipeline 12 as it is being laid shall now be described. Apparatus 10 is similar to that described in GB2303895B, the entire disclosure of which is incorporated herein by reference.

Apparatus 10 preferably includes an intake filter 14 that is capable of straining the surrounding seawater to remove substantially all of the contaminants before it is allowed to enter the pipeline 12. However, it is sufficient for the intake filter 14 to strain the seawater to the required standard only, and need not necessarily remove all contaminants. The intake filter 14 is also preferably capable of providing water at a flow rate necessary to flood the pipeline 12.

The intake filter 14 is coupled to the end 12a of the pipeline 12 *via* a conduit 16 that includes an orifice plate 18, a variable choke, generally designated 20, and an isolating valve 22. The variable choke 20 can be used to adjust the flow of water into the pipeline 12 to compensate for the varying hydrostatic head, and is automatically controlled in response to the existing rate of flow by use of differential pressure lines 24, 26. One pressure line 24, 26 is coupled to a first side of the orifice plate 18, and the other line 24, 26 is coupled to the other side of the plate 18.

Alternatively, the variable choke 20 can be automatically controlled using a pressure-operated device such as a diaphragm that is coupled to each side of the orifice plate 18.

As the pipeline 12 is laid from the lay barge 2, the pipeline 12 can be provided from the reel or drum 6 (as shown schematically in Fig. 1) or can comprise a number of lengths of pipe that are welded together on the lay barge 2 and then lowered into the sea. The latter method is generally used where the pipe is of a large diameter and cannot be wound onto a reel or drum. The laying operation can often be stopped and started, particularly in the latter method, and this can cause problems where chemicals are to be added or injected into the seawater that enters the pipeline 12. The flow rate of seawater into the pipeline 12 is generally not constant if the laying process is continually stopped and started, and thus it can be difficult to provide the correct dosage of injected chemicals into the water.

The variable choke 20 is generally used to keep the water level at a near constant in the rising portion 12r of the pipeline 12 (see Fig. 1). The variable choke 20 is used to ensure that there is at least a minimum flow of seawater into the pipeline 12 even where the laying process is stopped and started. This allows the chemical additives to be injected into the seawater at the correct dosage more easily by maintaining a substantially constant flow of water into the pipeline 12.

The isolating valve 22 is used to control the flooding of the pipeline 12 and in particular is used to initiate the process of flooding the pipeline 12. The isolating valve 22 is typically opened at the surface before the apparatus 10 and the end 12a of the pipeline 12 are lowered to the seabed 4. Thus, flooding of the pipeline 12 is initiated as it is being laid, thereby increasing the weight of the pipeline 12 as it is being laid. The increase in weight during laying of the pipeline 12 due to the intake of water has the potential to allow the wall thickness of the pipeline 12 to be reduced. This is because the weight of the pipeline 12 is being increased by the flooding action of apparatus 10, and thus the pipeline 12 is relatively heavy as it is laid on the seabed 4, or at least shortly after.

Thus, there is no requirement to increase the wall thickness of the pipeline 12 purely for stability during and after the laying operation. The pipeline 12 can thus comprise conventional pipe with a standard wall thickness that does not have to be increased purely for stability purposes. Thus, a pipeline with a reduced wall thickness (a reduction of around 3mm or more being typical) when compared with pipeline used in conventional methods, over the entire length of the pipeline 12 (typically many kilometres and possibly hundreds of kilometres in length) has the potential for significant cost savings. It will be appreciated that a pipeline with an increased wall thickness is more expensive than standard pipeline due to the additional material that is required to add weight purely for stability purposes. Furthermore, the equipment on the lay barge 2 does not have to handle the heavier pipeline that has increased wall thickness, thus also providing cost savings.

There can also be savings in terms of time as the pipeline 12 with the reduced wall thickness is easier to handle and can thus be laid more quickly. This also has the potential to reduce costs as the lay barge 2 is required for a lesser amount of time.

Furthermore, the pipeline 12 is more lightweight and smaller than the pipeline with the increased wall thickness and thus more of the pipeline 12 can be stored on the lay barge 2 and in a more compact area. This also has the potential to save costs as the additional amount of pipeline 12 that can be stored on-board the barge 2 results in the stock having to be replenished less often by a service vessel or the like, thereby saving on associated costs.

The apparatus 10 optionally includes an injection pump 28 that is capable of injecting or pumping additive chemicals into the conduit 16 and thus the pipeline 12. The additive chemicals are typically stored in a reservoir 30, although it will be appreciated that a number of reservoirs 30 and/or pumps 28 may be used, depending on the particular chemicals that are to be added to the seawater. The injection pump 28 is driven from a high-pressure supply 32 through an injection control valve 34. The injection control valve 34 can control the flow of the injected chemicals according to the prevailing hydrostatic pressure, or at a flow rate that varies with the water flow rate into the pipeline 12 (e.g. to be approximately proportional to the amount of water flowing into the pipeline 12). The latter can be derived from a pressure differential across the orifice plate 18 via differential pressure lines 36, 38. Alternatively, the injection pump 28 can be driven from a system of fixed or variable orifices that can control the rate of adding of the chemicals.

The differential pressure between the interior of the pipeline 12 and the surrounding seawater can also be used for chemical injection of additives. For example, a venturi, orifice or a fixed choke may be used where the venturi etc is coupled to a bag or the like of chemical additives at the orifice of the venturi. The bag or the like is typically at least partially flexible so that the pressure of the surrounding seawater can act on it. The pressure on one side of the venturi is typically at the same pressure as the surrounding seawater, and the pressure acting on the bag of additives is also at the same pressure as the surrounding seawater. The orifice in the venturi is at a lower pressure and thus the chemicals are sucked in from the bag because of the pressure differential. The pressure at the orifice will vary as the flow rate of water therethrough varies, and thus the chemicals are added in approximate proportion to the flow rate.

Thus, apparatus 10 facilitates chemical treatment of the seawater before it enters the pipeline 12 as it is being laid. This can be used for numerous purposes, such as for de-scaling, prevention of green growth, anti-corrosion and can also facilitate leak detection during pressure testing, as will be described. Thus, the chemical injection of selected additives provides numerous benefits over simply allowing untreated seawater to flood the pipeline 12.

Towards the completion of the pipe laying process, the hydrostatic pressure difference diminishes as the pipeline 12 floods, and the pressure difference between the interior of the pipeline 12 and the surrounding seawater will eventually decay to zero. This is dependent upon whether the distal end of the pipeline 12 remains on the lay barge 2 or is lowered to the seabed 4. If the distal end remains on the lay barge 2, flooding of the pipeline 12 may slow down or cease, but this may not be the case until substantially all of the pipeline 12 is laid on the seabed 4. It is therefore useful to provide a means by which pressurised water can be admitted to the pipeline 12 to completely flood it after the hydrostatic head has diminished. Where the distal end is lowered to the seabed (e.g. to be retrieved later for further extension to the pipeline 12), the distal end can be fitted with an air release valve. As the end is lowered to the seabed 4, the flooding of the pipeline 12 continues under the hydrostatic head of water above it and the air that remains in the distal end is vented through the air release valve.

In the embodiment shown in Fig. 2, a boost pump 40 is provided that is operable *via* a remotely operated valve 42. The valve 42 is typically controlled *via* a control line 43 from the surface, or may be operated by a diver, ROV or an autonomous vehicle (AUV). Alternatively, the valve 42 may be operated in response to a drop in the flow rate of water into the pipeline 12. The boost pump 40 can be powered from the surface or preferably from a local power supply such as from the ROV or some other power supply (e.g. batteries, hydraulic power source etc). The boost pump 40 is preferably located downstream of the injection pump 28 so that chemicals may be added to the water used to flood the pipeline 12.

Conduit 16 optionally includes a one-way or check valve 45 to prevent the flow of water back towards the intake filter 14.

The apparatus 10 optionally includes a pig (not shown) that is propelled along the pipeline 12 as it is being laid and flooded. The position of the pig within the pipeline 12 can be used as an indication of the amount of flooding, and thus it is desirable to track the location of the pig within the pipeline 12 and this can be done using any conventional means (e.g. a telemetry system). Use of a pig in certain embodiments provides the advantage that the flow rate of water into the pipeline 12 can be controlled. Further, as the movement and location of the pig in the pipeline 12 can be monitored, the extent of flooding of the pipeline 12 can also be monitored.

Additionally, it is advantageous to monitor the flow rate of the water into the pipeline 12 as it is being flooded. Thus, the apparatus 10 may include a flow recording device (not shown) such as a dial that can be read by an underwater camera provided on an ROV or AUV. The flow recording device can be of any conventional type, and can be electrically or otherwise coupled (e.g. *via* a telemetry system) to the surface for remote monitoring of the water flow rate.

Thus, apparatus 10 facilitates flooding of the pipeline 12 as it is being laid. This facilitates a reduction in the wall thickness of the pipeline 12 thereby having the potential to save money and time. Furthermore, the laying and flooding of the pipeline 12 can be achieved in one operation, thus providing further savings in terms of costs and time. This is particularly the case where the pipeline 12 would be laid using a lay barge 2 and then flooded using a large-bore, high-pressure conduit dropped from a support vessel (not shown). However, flooding of the pipeline 12 as it is being laid has the advantage that only the lay barge 2 or vessel is required, and this can significantly reduce costs by avoiding the use of an additional surface or support vessel that is normally required to flood the pipeline 12 (and optionally pressure test it).

The cost of the operation can be reduced further by using the apparatus 10 described above to pressure test the pipeline 12 once it has been laid and flooded to ensure that there are no fluid leaks, as this is generally desirable.

To provide for the pressure testing of the pipeline 12, apparatus 10 includes a low-flow rate but high-pressure pump 50 so that the pressure testing (also called hydro testing) can follow the laying and flooding of the pipeline 12 without the intervention of a support or surface vessel, or at least to a lesser extent than is conventional in the art.

Pump 50 is coupled into a conduit 52, the inlet of which is preferably coupled downstream of the injection pump 28 so that chemicals can be added to the water if required. The operation of pump 50 is controlled by a remotely operated valve 54 that can be operated *via* a control line 56 from the surface, or can be actuated by a diver, ROV or AUV. Alternatively, the valve 54 may be operated automatically when the flooding of the pipeline 12 is complete. An isolating valve 58 is located in the conduit 52 upstream of the pipeline 12 so that the conduit 52 can be opened and closed as required.

The pump 50 is actuated to provide a high-pressure flow of water, typically at a relatively low flow rate, into the pipeline 12. The high-pressure, low-flow of water increases the pressure within the pipeline 12 so that any leaks or weak points in the pipeline 12 can be detected. Chemicals may be added to the seawater to facilitate identifying the source of any leaks.

Only a relatively low flow rate of water is required as the pipeline 12 is already filled with seawater and only the internal pressure within the pipeline 12 need be increased. The volume of water that enters the pipeline 12 is considerably less than that required to flood it.

Referring now to Fig. 4 there is shown as an example a 12-inch (approximately 300 millimetre) bore pipeline 200 that is 5 kilometres long and has been laid on the seabed 202 between two installations 204, 206 in a deep-water field. Apparatus 10 is coupled to the pipeline 200 using a conduit 208 that is coupled to a pipeline inlet port, for example. Apparatus 10 is typically used to flood the pipeline 200 and can then be used to pressure test it in consecutive operations.

The flooding of the pipeline 200 typically requires a volume of water to fill the pipeline 200 (e.g. using the above described apparatus 10) that is in the order of 360 cubic metres. The additional volume of water required to raise the internal pressure of the pipeline 200 to around 700 bar (10150 psi) is 14½ cubic metres. This is only a small percentage (in the order of 4%) of the volume of water required to fill the pipeline 200 in the first instance, and highlights the difference in required capacity between a relatively low-pressure, high flow-rate flooding pump (e.g. boost pump 40) and a high-pressure, low-flow pressure testing pump (e.g. pump 50).

The pump 50 used for the pressure test typically requires to pressurise the pipeline 200 at approximately 1 bar per minute, and thus the required flow rate from pump 50 would be in the order of 21 litres per minute. If the pipeline 12 is to be pressured at around 3 bars per minute, then the corresponding flow rate is around 62 litres per minute.

Thus, the power required to provide these flow rates at the required pressures would reach a maximum as the final pressure is approached, and this maximum would be around 23 kilowatts (31 horse power) for the 1 bar per minute flow rate, and 60 kilowatts (94 horse power) for the 62 litres per minute flow rate.

Thus, the total energy required to pressurise the pipeline 200 during the pressure test is typically around 500 MJ. This energy can be provided by dropping an electrical cable from a supply vessel and coupling this to the pump 50. However, this has a drawback in that the surface vessel would require to remain *in situ* until the pressure test is complete, and this may take several hours as the pressure needs to be increased to the predetermined testing pressure, and then held at that pressure for a period of time, typically in the order of 24 hours.

It is therefore preferred that the energy required to drive the pump 50 is provided locally (i.e. subsea) as this has the advantage that the surface vessel is not required to remain *in situ* during the pressure test, providing significant costs advantages.

For example, the energy can be provided by a local (subsea) power supply such as a bank of suitable batteries. The batteries can be charged during flooding of the pipeline 200 by coupling an alternator or the like into the conduit 16 at an appropriate place so that the flow rate through the conduit 16 drives a turbine in the alternator that generates a sufficient current to charge the batteries.

It is preferred that the power to the pump 50 is provided locally so that there is no surface connection, although this may be possible in relatively shallow water or where there is access to a surface vessel. There is also the potential to use a smaller boat with less personnel as the pump used for pressure testing would not be required on board the vessel; all that is required is an electrical cable to be dropped to the seabed 202 for coupling to the apparatus 10 (e.g. by ROV 210).

As an alternative to using power from batteries or from an electrical cable from a surface vessel, the power for the pump 50 may also be provided by the ROV 210 or an autonomous vehicle (AUV - not shown). This would require the pump 50 to be provided with a suitable connector that can be engaged and disengaged by the ROV 210 or AUV so that power can be provided. Alternatively, an electrical cable 212 can be coupled between the pump 50 and the ROV 210 (see Fig. 4). Thus, the ROV 210 or AUV would be coupled to the pump 50 in any conventional manner to provide power thereto, and then de-coupled once the pressure test is complete.

Alternatively, the pump 50 may be pneumatically or hydraulically powered, the latter possibly being provided by the ROV 210 as this can provide hydraulic power.

It will be appreciated that the above apparatus 10 has been described where the pump 50 forms a part of the apparatus 10, but it will also be appreciated that the pump 50 may be provided on a separate subsea skid from the remainder of the apparatus 10, 100. Having the pump 50 included in a single subsea skid with the remainder of the apparatus 10 provides the advantage that only a single piece of equipment need be lowered to and retrieved from the seabed. Additionally, the apparatus 10 need only be coupled to the pipeline once in order to flood it and pressure test it. There is no requirement to couple and de-couple other equipment to the pipeline using an ROV for example. Both of these are significant advantages when the time taken to raise and lower the apparatus 10 is considered, and also the time taken to couple and de-couple conventional large-bore conduits.

Indeed, the pump 50 can be used independently of the remainder of the apparatus 10 that is generally used to flood the pipeline 12. The pump 50 can be provided on a separate subsea skid and coupled to and de-coupled from the pipeline 12 using a diver, ROV or AUV as necessary. Thus, the pump 50 does not have to be used with the remainder of the apparatus 10 described above, and could be used with other conventional methods of flooding the pipeline 12. However, it will be noted that combining the pump 50 with the remainder of the apparatus 10 has significant advantages in that the flooding and pressure testing of the pipeline 12 can be done in consecutive operations, without the intervention of a vessel, and without having to de-couple and couple other equipment and apparatus.

Referring now to Fig. 3, there is shown an alternative embodiment of apparatus 100 for flooding and pressure testing a pipeline 112. Apparatus 100 is shown in Fig. 3 as attached to the end 112a of the pipeline 112 and is similar to apparatus 10, so like numerals prefixed "1" have been used to designate like parts.

In the embodiment shown in Fig. 3, the pump 50 has been replaced by a gas accumulator bottle or a bank of such, generally designated 160, that is capable of providing high-pressure, low-flow gas into a reservoir 162 or other container of seawater. As the flow of gas from the accumulator bottles 160 (typically *via* a manifold (not shown) so that the gas flow rate can be controlled) enters the reservoir 162, the water therein is forced into the pipeline 112, preferably at high pressure and a low flow rate. The water already in the pipeline 112 is compressed, thus increasing the internal pressure to perform the pressure tests. This particular embodiment is advantageous as an electrical power supply is not required.

The gas bottles 160 can be filled with gas (e.g. air or the like) at the surface before the apparatus 100 is lowered to the seabed. A conduit 164 is coupled to the pipeline 112 so that the pressurised gas from the bottles 160 can enter the reservoir 162 and force pressurised water out of it and into the pipeline 112. A remotely-operated isolating valve 166 is coupled into the conduit 162 so that the flow of water into the pipeline 112 can be controlled from the surface (e.g. using a control line 166), or otherwise controlled (e.g. automatically in response to the pressure within the pipeline 112).

The gas bottles 160 may include a regulating device (not shown) to control the rate at which gas enters the reservoir 162 and also to control the pressure of the water from the reservoir 162 as it enters the pipeline 112. The regulating device can be of any conventional type, and could be a further remotely operated valve that can be controlled from the surface or by a diver, ROV or AUV, or automatically.

Embodiments of the present invention provide numerous advantages over conventional methods for the laying and flooding of pipelines. In particular, there is the potential to reduce costs and time, in addition to using lighter and easier to handle pipe. Also, there is no requirement to use a support vessel at the surface to flood and/or pressure test the pipeline, thus saving significant costs in terms of manpower and the operation of the vessel. Furthermore, the present invention can be used to flood the pipeline as it is being laid, and then to pressure test it in consecutive operations; there is no requirement to couple and de-couple various pumps and other apparatus and equipment to the pipeline in order to lay it, flood it and then pressure test it.

Modifications and improvements may be made to the foregoing without departing from the scope of the present invention.

CLAIMS

1. A method of flooding a pipe as it is being laid in water, the method comprising the steps of providing an inlet to the pipe, the inlet having an opening to admit water, and allowing water to enter the pipe through the inlet as the pipe is being laid.

2. A method according to claim 1, wherein the method includes the additional steps of coupling a pipe inlet port to the pipe, and coupling the inlet to the pipe inlet port.

3. A method according to claim 2, wherein the method includes the additional step of coupling the inlet to the pipe before the pipe enters the water.

4. A method according to claim 2, wherein the method includes the additional step of coupling the inlet to the pipe underwater.

5. A method according to any preceding claim, wherein the method includes the additional step of actuating flooding of the pipe.

6. A method according to claim 5, wherein the step of actuating flooding of the pipe involves opening an isolating valve.

7. A method according to any preceding claim, wherein the method includes the additional step of filtering the water that enters the pipe.

8. A method according to any preceding claim, wherein the method includes the additional step of providing an intake filter at the inlet.

9. A method according to any preceding claim, wherein the pipe is flooded from the end that is in the water.

10. A method according to any preceding claim, wherein a hydrostatic head of water above the pipe is used to flood the pipe.

11. A method according to any preceding claim, wherein an end of the pipe provides a vent to the atmosphere for the air or gas in the pipe during flooding.

12. A method according to any preceding claim, wherein the method includes the additional step of adding chemicals to the water that enters the pipe.

13. A method according to any preceding claim, wherein the method includes the additional step of pumping fluid into the pipe to complete flooding of the pipe.

14. A method according to claim 13, wherein the step[of pumping fluid into the pipe comprises actuating a pump to complete flooding of the pipe.

15. A method according to any preceding claim, wherein the method optionally the additional step of pressure testing the pipe after it has been flooded.

16. A method according to claim 15, wherein the step of pressure testing the pipe involves the actuation of a subsea pump.

17. A method of laying a pipeline in a body of water, the method comprising allowing the water to flood the pipeline as it is being laid.

18. A method according to claim 17, wherein the method includes the steps of providing an inlet to the pipeline, the inlet having an opening to admit water, and allowing water to enter the pipeline through the inlet as the pipeline is being laid.

19. A method according to claim 18, wherein the method includes the additional steps of coupling a pipe inlet port to the pipe, and coupling the inlet to the pipe inlet port.

20. A method according to claim 19, wherein the method includes the additional step of coupling the inlet to the pipe before the pipe enters the water.

21. A method according to claim 19, wherein the method includes the additional step of coupling the inlet to the pipe underwater.

22. A method according to any one of claims 17 to 21, wherein the method includes the additional step of actuating flooding of the pipe.

23. A method according to claim 22, wherein the step of actuating flooding of the pipe involves opening an isolating valve.

24. A method according to any one of claims 17 to 23, wherein the method includes the additional step of filtering the water that enters the pipe.

25. A method according to any one of claims 17 to 24, wherein the method includes the additional step of providing an intake filter at the inlet.

26. A method according to any one of claims 17 to 25, wherein the pipe is flooded from the end that is in the water.

27. A method according to any one of claims 17 to 26, wherein a hydrostatic head of water above the pipe is used to flood the pipe.

28. A method according to any one of claims 17 to 27, wherein an end of the pipe provides a vent to the atmosphere for the air or gas in the pipe during flooding.

29. A method according to any one of claims 17 to 28, wherein the method includes the additional step of adding chemicals to the water that enters the pipe.

30. A method according to any one of claims 17 to 29, wherein the method includes the additional step of pumping fluid into the pipe to complete flooding of the pipe.

31. A method according to claim 30, wherein the step of pumping fluid into the pipe comprises actuating a pump to complete flooding of the pipe.

32. A method according to any one of claims 17 to 31, wherein the method optionally the additional step of pressure testing the pipe after it has been flooded.

33. A method according to claim 32, wherein the step of pressure testing the pipe involves the actuation of a subsea pump.